WE CLAIM:

1. An environmental and thermal barrier coating, comprising:

a layer of a composition comprising at least about 50 mole % $AlTaO_4$, and the balance comprising at least one metal oxide selected from the group consisting of Ta, Al, Cr, Hf, Ti, Zr, Mo, Nb, Ni, Sr, Mg, Si, and the rare earth elements including Sc, Y, and the lanthanide series of elements, wherein said layer of said composition has a coefficient of thermal expansion (CTE) in the range of from about 3.5×10^{-6} $°C^{-1}$ to 5×10^{-6} $°C^{-1}$, and a thickness in the range of from about 0.1 to 50 mils.

2. The environmental and thermal barrier coating of claim 1, wherein said composition has a coefficient of thermal expansion (CTE) in the range of from about 4×10^{-6} $°C^{-1}$ to 5×10^{-6} $°C^{-1}$.

3. The environmental and thermal barrier coating of claim 1, wherein said layer of said composition has a thickness in the range of from about 0.1 to 20 mils.

4. The environmental and thermal barrier coating of claim 1, wherein said layer of said composition has a thickness in the range of from about 0.5 to 10 mils.

5. The environmental and thermal barrier coating of claim 1, wherein said composition comprises at least about 50 mole % $AlTaO_4$, and the balance consists essentially of Al_2O_3.

6. The environmental and thermal barrier coating of claim 1, wherein said composition comprises at least about 50 mole % $AlTaO_4$, and the balance consists essentially of Ta_2O_5.

7. The environmental and thermal barrier coating of claim 1, wherein said composition comprises at least about 90 mole % $AlTaO_4$.

8. The environmental and thermal barrier coating of claim 1, wherein said composition consists essentially of $AlTaO_4$.

9. The environmental and thermal barrier coating of claim 1, wherein said composition is prepared by reacting a starting powder mixture to form said $AlTaO_4$, said starting powder mixture comprising at least about 45 mole % Ta_2O_5 and at least about 45 mole % Al_2O_3.

10. The environmental and thermal barrier coating of claim 1, wherein said layer of said composition is deposited by an air plasma spray process.

11. An environmental and thermal barrier coating, comprising:

a layer of a composition comprising at least about 99 mole % $AlTaO_4$, wherein said environmental and thermal barrier coating has a coefficient of thermal expansion (CTE) in the range of from about 4×10^{-6} °C^{-1} to 5×10^{-6} °C^{-1}.

12. A thermally protected component, comprising:

a substrate having a surface; and

an environmental and thermal barrier coating disposed on said surface of said substrate, wherein said environmental and thermal barrier coating comprises at least about 50 mole % $AlTaO_4$, and the balance consists essentially of Ta_2O_5 or Al_2O_3, and wherein said environmental and thermal barrier coating is characterized by a coefficient of thermal expansion (CTE) in the range of from about 4×10^{-6} °C^{-1} to 5×10^{-6} °C^{-1}.

13. The thermally protected component of claim 12, wherein said substrate comprises a silicon-based ceramic or composite, said substrate having a coefficient of thermal expansion (CTE) in the range of from about 4 x 10^{-6} $°C^{-1}$ to 5 x 10^{-6} $°C^{-1}$.

14. A thermally protected component, comprising:

a substrate having a surface; and

an environmental and thermal barrier coating disposed on said surface of said substrate, wherein said environmental and thermal barrier coating comprises at least about 50 mole % $AlTaO_4$, and the balance comprises at least one metal oxide selected from the group consisting of Ta, Al, Cr, Hf, Ti, Zr, Mo, Nb, Ni, Sr, Mg, Si, and the rare earth elements including Sc, Y, and the lanthanide series of elements.

15. The thermally protected component of claim 14, wherein said at least one metal oxide comprises Al_2O_3 or Ta_2O_5.

16. The thermally protected component of claim 14, wherein said environmental and thermal barrier coating comprises at least about 90 mole % $AlTaO_4$.

17. The thermally protected component of claim 14, wherein said environmental and thermal barrier coating comprises greater than 99 mole % $AlTaO_4$.

18. The thermally protected component of claim 14, wherein said substrate comprises a silicon-based ceramic or composite.

19. The thermally protected component of claim 14, wherein said substrate comprises a SiC-SiC composite or a Si_3N_4 composite.

20. The thermally protected component of claim 14, wherein said environmental and thermal barrier coating has a stable crystalline structure at a temperature of about 1550°C.

21. The thermally protected component of claim 14, wherein said environmental and thermal barrier coating has a thickness in the range of from about 0.1 to 20 mils.

22. The thermally protected component of claim 14, wherein said substrate comprises a component of a gas turbine engine.

23. A method for preparing an environmentally and thermally protected component, the method comprising:

a) providing a mixture of Ta_2O_5, or a precursor thereof, and Al_2O_3, or a precursor thereof;

b) reacting said mixture to provide a reaction product comprising at least about 50 mole % $AlTaO_4$; and

c) depositing a layer of said reaction product on a surface of said component to form an environmental and thermal barrier coating disposed on said surface of said component.

24. The method of claim 23, wherein said mixture provided in said step a) comprises at least about 25 mole % Ta_2O_5 and at least about 25 mole % Al_2O_3.

25. The method of claim 23, wherein said environmental and thermal barrier coating has a coefficient of thermal expansion (CTE) in the range of from about 4×10^{-6} °C^{-1} to 5×10^{-6} °C^{-1}.

26. The method of claim 23, wherein said step b) comprises heating said mixture in air at a temperature in the range of from about 1300 to 1600°C.

27. The method of claim 23, further comprising:

d) after said step b), providing particles of said reaction product, and wherein said step c) comprises depositing said layer of said reaction product on said surface of said component via a plasma spray process.

28. The method of claim 23, wherein said component comprises a silicon-based component of a gas turbine engine, and said environmental and thermal barrier coating has a thickness in the range of from about 0.1 to 50 mils.

29. The method of claim 23, wherein said environmental and thermal barrier coating formed in said step c) comprises at least about 90 mole % $AlTaO_4$, and the balance comprises at least one of Al_2O_3 and Ta_2O_5.

30. The method of claim 23, wherein said environmental and thermal barrier coating formed in said step c) consists essentially of $AlTaO_4$.

31. A method for making an environmentally and thermally protected component, comprising:

a) providing a composition comprising at least about 90 mole % $AlTaO_4$, and the balance consisting predominantly of a metal oxide selected from the group consisting of Al_2O_3 and Ta_2O_5;

b) providing a substrate having a surface to be coated; and

c) depositing a layer of said composition on a surface of said substrate to form an environmental and thermal barrier coating thereon, said environmental and thermal barrier coating having a coefficient of thermal expansion (CTE) in the range of from about 4×10^{-6} °C^{-1} to 5×10^{-6} °C^{-1}, and a thickness in the range of from about 0.1 to 50 mils.

32. The method of claim 31, wherein said step a) comprises:

d) providing a mixture comprising at least about 45 mole % Ta_2O_5 and at least about 45 mole % Al_2O_3; and

e) heating said mixture to form said composition.

33. The method of claim 31, wherein said environmental and thermal barrier coating formed in said step c) comprises at least about 99 mole % $AlTaO_4$.

34. The method of claim 31, wherein said substrate comprises a silicon-based ceramic or composite having a coefficient of thermal expansion (CTE) in the range of from about 4 x 10^{-6} °C^{-1} to 5 x 10^{-6} °C^{-1}.

35. The method of claim 31, wherein said component comprises a gas turbine engine component.

36. A method for making an environmentally and thermally protected component, comprising:

a) providing a substrate to be coated with an environmental and thermal barrier coating, said substrate comprising silicon carbide;

b) providing a composition comprising at least about 90 mole % $AlTaO_4$, and the balance comprising an oxide of an element selected from the group consisting of Ta, Al, Cr, Hf, Ti, Zr, Mo, Nb, Ni, Sr, Mg, Si, and the rare earth elements including Sc, Y, and the lanthanide series of elements; and

c) depositing a layer of said composition on a surface of said substrate to form said environmental and thermal barrier coating, each of said substrate and said environmental and thermal barrier coating having a coefficient of thermal expansion (CTE) in the range of from about 4 x 10^{-6} °C^{-1} to 5 x 10^{-6} °C^{-1}.

37. The method of claim 36, wherein said step b) comprises:

d) combining Ta_2O_5, or a precursor thereof, and Al_2O_3, or a precursor thereof, to form a mixture comprising at least about 45 mole % Ta_2O_5 and at least about 45 mole % Al_2O_3; and

e) heating said mixture to provide a reaction product comprising at least about 90 mole % $AlTaO_4$.

38. The method of claim 36, wherein said substrate comprises a gas turbine engine component.

39. An environmental and thermal barrier coating formed according to the method of claim 36.